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This project has studied the distribution of particle reactive natural and artificial radionuclides in sediment cores of the Ob River, Siberia in order to determine the release and transport of nuclides from nuclear weapons related activities of the former Soviet Union. The Ob River drainage basin houses the bulk of the former Soviet Union's weapons production facilities (Mayak and Tomsk-7) as well as the major test site of Semipalatinsk. In addition, some 2 billion curries of nuclear waste from weapons production are stored or have been released to the environment in this area. The potential for catastrophic future releases from poorly maintained tanks and open storage ponds is real. This project has sought to develop a history of transport and deposition of nuclides released from these plants, and to use these data as a basis for estimating delivery to the Arctic Ocean and to predict rates of transport in the event of future releases.

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Title: Assessment of the Fate of Radioactive Contaminants in the Ob River

A. Approaches and Objectives:

This project has studied the distribution of particle reactive natural and artificial radionuclides in sediment cores of the Ob River, Siberia in order to determine the release and transport of nuclides from nuclear weapons related activities of the former Soviet Union. The Ob River drainage basin houses the bulk of the former Soviet Union's weapons production facilities (Mayak and Tomsk-7) as well as the major test site of Semipalatinsk. In addition, some 2 billion curries of nuclear waste from weapons production are stored or have been released to the environment in this area. The potential for catastrophic future releases from poorly maintained tanks and open storage ponds is real. This project has sought to develop a history of transport and deposition of nuclides released from these plants, and to use these data as a basis for estimating delivery to the Arctic Ocean and to predict rates of transport in the event of future releases.

The study is based on the determination of profiles of a number of particle reactive nuclides in sediment cores collected from the flood plain of the Ob River. In many of the lakes, these studies demonstrate that mixing of the sediment is minimal. As a consequence, the sediments preserve a record of the material transported down the Ob and deposited on the flood plain. With cores 50 –100 cm in length, the record extends back to the beginning of the nuclear age, e.g. before 1945. Expeditions in 1994 and 1995 collected a series of cores that extend from the delta region to the Irtysh above its confluence with the Tobol. Cores collected on the Ob above the Irtysh, the Tobol, and the Irtysh above the Tobol make it possible to determine contaminant sources as the upper Ob drains the Tomsk area; the Tobol drains the Mayak area, and the Irtysh flows through Semipalatinsk. The Nuclides we have studied include ^{137}Cs, ^{237}Np, ^{239}Pu, ^{240}Pu, and the natural nuclide ^{210}Pb for establishing chronologies.

Our specific objectives :

1. To determine if lake sediments preserve a record of transport and deposition of weapons related particle reactive nuclides.
2. Estimate delivery of weapons plant releases of these nuclides to the Arctic Ocean.
3. Estimate transport rates down the course of the river.
4. Establish a predictive capability for transport in the event of future releases.

B. Conclusions:

1. The lake sediments preserve a detailed record of weapons related nuclide transport and deposition. Sedimentation rates in the delta are such that resolution of events is a few years. Higher rates in the mid-reaches of the river make it possible to establish events with about 1 year resolution.

2. The great majority of the Pu carried by the Ob originates as global fallout. Consequently, the net delivery from the Ob is less than that of temperate latitude rivers where fallout inventories are greater. However, weapons grade Pu is present throughout much of a delta core studied, comprising about 5-10% of the Pu. In three discrete horizons the weapons component rises to as much as one-half of the total. These years indicate abnormal periods when weapons grade Pu was as abundant as fallout, still low levels, however.
3. The Ob above the Irtysh is chronically contaminated with weapons grade Pu. $^{240}Pu/^{239}Pu$ ratios that from the earliest days (~1950) ratios were ~ 1/2 that of fallout, indicating weapons Pu about equal to fallout. The Tobol does not show such contamination, at least in post-1975 sediments. Thus it is almost certain that the Tomsk plant is a major source of weapons Pu in the delta.
4. After 1980 $^{237}Np/^{239}Pu$ ratios rise rapidly above fallout in the delta core, indicating release of this nuclide into the river upstream. Ratios rise to twice fallout indicating a dominance of local sources over fallout. In the Ob above the Irtysh ratios reach six times fallout, whereas those in the Tobol are close to fallout. As with Pu, the Tomsk plant is the likely source.
5. The timing of the Np peak in the upper Ob and the delta indicate rapid transport of this nuclide. It appears to transit the 1000+ km of river in less than a few years, possibly a single season. The character of the Pu peaks in the delta suggests similarly rapid transport, but this case is less clear as there are no corresponding peaks in the upper Ob, just constant contamination.
6. As regards prediction- the rapid transport of the Np from the upper Ob indicates efficient and rapid transport down the river. Given that both Pu and Np are particle reactive, a similar rate of transport should be assumed for Pu unless evidence to the contrary is presented. We are continuing to address this issue.

Publications (Including Theses):

Pantaleyev, G. P. (1995) The History of Plutonium and Cesium-137 Contamination of the Ob River Delta Sediments. M.Sc. Thesis; Woods Hole Oceanographic Institution/ Massachusetts Institute of Technology Joint Program. 139pp.

Sayles, F. L., H. D. Livingston, and G. P. Panteleyev (1997). The History and Source of Particulate ^{137}Cs and $^{239,240}Pu$ Deposition in Sediments of the Ob River Delta, Siberia. *Journal of the Total Environment* . **202**: 25-41.

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Sayles, F. L., T. C. Kenna, and H. D. Livingston (1998) Release and transport of artificial radionuclides from nuclear weapons related activities in the Ob River, Siberia. International Symposium on Marine Pollution, Monaco. 5-9 Oct, 1998. p627-628.